HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG UFZ

EnergyLandUse

Book of abstracts

UFZ EnergyDays 2016

22-23 March, KUBUS Leipzig

Workshop abstract:

The workshop has been initiated by the UFZ Integrated Project "EnergyLandUse – Land Use Aspects of Transforming the Energy System". It provides a platform to discuss challenges and recent progress in research on renewable energies and on the transition towards decarbonisation and bioeconomy. It is about technological solutions and socio-environmental implications of using renewable resources for energy and material supply in circular economies. In an interdisciplinary context, including a spatially explicit approach, technological and institutional options will be looked at in their systemic interplay to foster sustainability.

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12:45	**Keynote** Dr. Harry Lehmann, German Federal Environmental Agency (UBA)		
13:30	*Coffee break*		
13:45	**Research highlights** of the Integrated Project "EnergyLandUse"		
15:45	*Coffee break*		
16:30	**Session A1** Social implications of synthetic biology in energy production → *Sarah Hackfort (IZT), Conrad Kunze (UFZ)* * Synthetic biology and its political and social context *Conrad Kunze, Sarah Hackforth* * Synthetic biology – The next phase of biotechnology and genetic engineering *Steffen Albrecht* * Phase out model *Homo Sapiens* *Thomas Wagner* * The bioeconomy and land grabs in Latin America – Experiences and outlook *Thomas Fatheuer* * Can synthetic biology really make biofuels more sustainable? *Almuth Ernsting* * Biotechnology and financial markets *Kean Birch*	**Session B1** Microbial processes for recovery of critical metals from secondary resources → *Birgit Daus (UFZ)* * Reductive bioleaching for metal recovery from oxide ores *Axel Schippers* * Metallophores selectively bind metals *Dirk Tischler* * Correlative microscopy for analysing dissolution of minerals and electron transfer processes as a key step for development of bio-mining concepts *Niculina Musat* * Speciation analysis – A tool for identification and quantification of metal compounds *Birgit Daus*	**Session C1** High shares of volatile renewables in the electricity mix: How to activate flexibility options in the power supply system? → *Klaas Korte (UFZ)*
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Wednesday, 23 March 2016			
11:30	**Session A3** From energy transition to bioeconomy – Challenges for the governance of sustainable material flows → *Erik Gawel (UFZ), Wolfgang Köck (UFZ)* * Bioeconomy – Opportunity for a sustainable society? *Steffi Ober* * Challenges to sustainable biomass supply *Iris Lewandowski* * Economic and legal challenges of the transition towards a sustainable wood-based bio-economy *Erik Gawel* * Sustainability evaluation tools as governance instruments in the bioeconomy *Roland Essel*	**Session B3** Industrial biotechnology concepts making use of renewable resources II → *Bruno Bühler (UFZ), Sabine Kleinsteuber (UFZ)* * High value from specialized plant natural products: From source to biocatalytic conversion *Ludger Wessjohann* * Biotechnological concepts for chemical and polymer production in the context of bio-economy *Jochen Schmid* * *Synechocystis* biofilms as solar driven biocatalysts *Katja Bühler* * Biocatalytic H_2 production under aerobic conditions: Challenges and opportunities *Oliver Lenz*	**Session C3** Exploitation of subsurface resources for thermal and substantial energy storage within the context of the transformation of the energy system → *Sebastian Bauer (CAU), Olaf Kolditz (UFZ)* * Quantifying induced effects of subsurface renewable energy storage – The ANGUS+ project *Sebastian Bauer* * Thermo-mechanical modelling of cyclic gas storage applications in salt caverns *Norbert Böttcher* * Quantification of storage capacities and withdrawal rates of high-temperature heat storages in the subsurface *Anke Boockmeyer* * Impact factors on the long term economic efficiency and environmental sustainability of borehole heat exchanger systems for the use of shallow geothermal resources *Haibing Shao* * Data integration workflow and interactive visualization of potential salt cavern regions *Lars Bilke* * Legal option to deal with diverging claims concerning use of underground space *Jana Bovet*
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Abstracts

Session A1: Social implications of synthetic biology in energy production

Session coordinators and chairpersons: [1] ***Sarah Hackfort,*** [2] ***Conrad Kunze***

[1] Head of Research Sustainability and Transformation, Institute of Future Studies and Technology Assessment, Berlin, Germany

[2] Department of Urban and Environmental Sociology, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: [1] s.hackfort@izt.de, [2] conrad.kunze@ufz.de

The rapidly emerging field of Synthetic Biology (SB) opens dimensions of nature to planed alterations of DNA and even creation of new organisms by humans yet unseen. In the multifold fields of application, energy is one major topic. SB is already applied in R&D projects in large scale algae cultivation in Central America, it allows for new forms of genetically manipulated short rotation crops, possibly as part of the so called climate smart agriculture program (CSA) and research efforts are made for microorganisms that could increase exploitable global gas reserves by 40-60% (ETC/HBS 2015a).

As industrial use of SB microorganisms as part of the bioeconomy begins to produce supplements for palm oil, vanilla, vetiver and many other high value food products, the share of original products in land use and markets might drop and dependence on biomass, e.g. sugar cane might rise.

The session will address the social consequences of SB in different fields of its application, to sketch a social science research agenda. One main question is, how SB really differs from conventional DNA manipulation, how it is part of the bioeconomy and how energy production will be affected.

The 90 Minute session is definitely too short to explain technical details of SB. Therefore participants are urgently asked to prepare in advance. An introduction can be found obviously at Wikipedia, for the newer developments see:

- UN Convention on Biological Diversity (COP)/UNEP 2014, Report 82, Synthetic Biology.
- ETC/HBS, 2015a, Extreme Biotech meets Extreme Energy.
- ETC/HBS, 2015b, Outsmarting Nature, New Report Questions Risky Synthetic Biology Developments Promoted Under “Climate-Smart” Guise.

Synthetic biology and its political and social context

A1

Conrad Kunze[1], Sarah Hackforth[2]

[1] Department of Urban and Environmental Sociology, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

[2] Head of Research Sustainability and Transformation, Institute of Future Studies and Technology Assessment, Berlin, Germany

Contact: conrad.kunze@ufz.de

For some, synthetic biology is only another biotechnology, but by others it is portrayed as a game changer in the field. What does that mean for the bio-economy? If synthetic biology was really a transformative technology, what kind of transformation is expectable and what is desirable?

Synthetic biology – The next phase of biotechnology and genetic engineering

A1

Steffen Albrecht

Institute for Technology Assessment and Systems Analysis (ITAS) and Office of Technology Assessment at the German Bundestag (TAB), Karlsruhe Institute of Technology, Karlsruhe, Germany

Contact: albrecht@tab-beim-bundestag.de

Synthetic biology is an emerging field of science and technology. Depending on the way it is defined, synthetic biology is still mostly a matter of basic research, or it is already influencing the markets, societies, and the environment. This presentation aims to give an overview of synthetic biology and its societal implications from the point of view of technology assessment, based on findings from a recent assessment report (Sauter et al., 2015). It will briefly discuss the definition of synthetic biology, present some case studies to highlight the actual and potential significance of the field in the context of the notion of a bioeconomy, and point to possible ways forward for the field as a whole.

While the notion of synthetic biology is more than 100 years old, the field actually emerged in the early 2000s in the US and in Europe. It has been the subject of increasing interest with regard to public and private funding activities and ethical and artistic reflection, whereas public awareness of and discourse about the field are still rather poorly developed. Today the very definition of synthetic biology is still disputed, but a number of applications exist on the market – and a much greater number of visions and ideas for future applications is being discussed among experts from fields such as biotechnology, physics, bioinformatics, but also art and the DIY and start up community.

From the point of view of technology assessment, synthetic biology in the narrow sense – mainly comprising future developments towards artificial biological systems – can be distinguished from synthetic biology in the broader sense – comprising techniques of genetic modification that are mostly application oriented and increasingly based on digital information. Focusing on synthetic biology in the broader sense, the presentation will highlight the state of play in various fields of application, especially in energy production. To exemplify the potential societal implications of synthetic biology it will introduce two case studies: one on the (future) role of digital information in biology, and one on the (current) role

of public discourse on the development of novel kinds of oil from algae. The insights from these case studies will lead to new questions about possible ways forward for synthetic biology as a field and about the role the social sciences can play in shaping it.

References:

Sauter, A., Albrecht, S., van Doren, D., König, H., Reiß, Th., Trojok, R. (2015): Synthetische Biologie – die nächste Stufe der Bio- und Gentechnologie. Endbericht zum TA-Projekt. Berlin: Büro für Technikfolgen-Abschätzung beim Deutschen Bundestag

Phase out model *Homo Sapiens*

A1

Thomas Wagner

freelance author

Contact: wagnerthom@gmx.de

For the transhumanist ideologists, the promises of synthetic biology are an essential building block for the desired technological singularity, which they associate with the prospect of unlimited material abundance and immortality. The material basis for the spread of this ideology is the triumph of digital platform-capitalism. Based on the example of the Californian Singularity University the presentation shows how economic monopoly power and fantastic ideas transform into a real threat for democracy.

The bioeconomy and land grabs in Latin America – Experiences and outlook

A1

Thomas Fatheuer

Land and Forest, Centre for Research and Documentation Chile-Latin America, Berlin, Germany

Contact: thomas.fatheuer@gmail.com

With the increased access to biomass and agricultural use for energy purposes, the bio-economy can deepen old divisions of the world. The global south is again perceived primarily as a supplier of raw materials and integrated into the world economy. Latin America, Africa and Southeast Asia offer what the bio-economy needs: a huge production of biomass and in Latin America and Africa allegedly surfaces that are only used extensively, but which were suitable for intensive agricultural production.

Can synthetic biology really make biofuels more sustainable?

A1

Almuth Ernsting

Biofuelwatch, United Kingdom

Contact: almuthbernstinguk@yahoo.co.uk

An outlook on the risks associated with the use of synthetic biology microorganisms in industrial settings for biofuel refining and the poor success rate of cellulosic and algal biofuels, including those relying on synthetic biology microorganisms.

Biotechnology and financial markets

A1

Kean Birch

Department of Social Science, York University, Toronto, Canada

Contact: kean@yorku.ca

Life science firms are asset-based enterprises rather than commodity-based ones, in that their value is derived from trade in intellectual property and financial investments, not from the production of biological commodities or materials.

Session A2: Bioeconomy workshop – Future trade-offs between alternative biomass resources

A2

Session coordinator and chairperson: ***Alberto Bezama***

Department of Bioenergy, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: alberto.bezama@ufz.de

The goal of transforming society in an equal, post fossil carbon society is currently streamlined through several structural, technological and societal initiatives at global and national scales. Sustainable development goals and thus the corresponding bioeconomy concepts currently being developed and/or implemented worldwide provide the basis for the establishment of national and local roadmaps for maximizing the use of the available biomass resources from a strategic perspective, considering the specific characteristics of the regions.

However, the implications of such strategies in relation to regional development are still largely unclear. The first step to determine the potential socio-economic and environmental implications of implementing the bioeconomy concept is through the identification of potential trade-offs between different alternative biomass uses.

This workshop intends to begin a dialogue which helps to identify what the potential trade-offs could be between different biomass uses. Additionally as such tradeoffs are predicted to occur at local and regional levels, understanding potential impacts at this scale will also be a key thread to the proposed dialogue.

AFASYS (Agrar-Forst-Aquatische Systeme der Zukunft) – Vision of a sustainable agricultural system

A2

Romann Glowacki

Coordinator for innovation processes, Deutsches Biomasseforschungszentrum (DBFZ), Leipzig, Germany

Contact: romann.glowacki@dbfz.de

As part of a collaborative work between several German research institutions involved in different sectors of the bioeconomy field, a vision of the agricultural system of the future was developed as means to understand the potential role of the agricultural system in a future bioeconomy. This concept was named AFASYS (Agriculture-Forest-Aquatic System of the Future: Heart of the bio-based Economy after 2030 – Bioeconomy 2.0").

The agricultural system of the future envisaged in the AFASYS concept depicts the decentralized production, provision and distribution of sufficient biomass amounts as a cornerstone to cover the diverse needs of the entire bioeconomy. It sets the agricultural system of the future at the centre of society, leading their change in consciousness and in creating an understanding of its limited resources. Moreover, this vision includes all forms of biomass production, processing, recycling and use, thus involving a much broader definition of the agricultural system as we know today.

However, developing our current agricultural system towards a more integrated concept such as the one envisaged by AFASYS implies the parallel evolution and integration of several

sectors, such as society (e.g. demand of new products, societal behavior), industry (e.g. infrastructure development and refurbishment, widening of raw material basis) as well as policy makers (e.g. further development and implementation of circular economy strategies).

Therefore, this presentation intends to present the vision of the future agricultural system described in the AFASYS, identifying the role of this agricultural system in the development of the bioeconomy field. Moreover, it intends to identify some the most relevant aspects for achieving this vision, as basis for the discussion to be held in this session.

Session A3: From energy transition to bioeconomy – Challenges for the governance of sustainable material flows

Session coordinators and chairpersons: [1] ***Erik Gawel,*** [2] ***Nina Hagemann,*** [3]***Wolfgang Köck***

[1,2] Department of Economics, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

[3] Department of Environmental and Planning Law, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: [1] erik.gawel@ufz.de, [2] nina.hagemann@ufz.de, [3] wolfgang.koeck@ufz.de

The energy transition is already regarded as a great challenge for long-term sustainability governance between market and state. The challenge is even greater for the bioeconomy with its sustainability orientation of all material flows (raw materials, biomass, water, waste, energy etc.) within an integrated future oriented system.

In contrast to already established policy fields such as energy, environment and climate policies, which are to be activated for the energy transition, bioeconomy policy is not yet an established policy field – at best it is a highly fragmented policy field that is shaped by a small group of actors. Moreover, it focuses mainly on research and development and here technological research dominates.

The aim of the session is to focus on the policy and research field bioeconomy from a social science perspective and address the societal challenges of sustainable material flow governance. Based on the experiences from the energy transition the following questions will be discussed:

i) Which criteria are to be fulfilled by the bioeconomy to contribute to create a social added value?

ii) What are the challenges and advantages provided by the current governance framework for the biobased economy and what are suitable instruments and governance architectures for the regulation between market and state? What are features of an adaptive governance architecture that supports the transition towards an environmental friendly and sustainable economy?

iii) How to secure sustainability of state governed material flows? How can the increasing competition for the use of biomass be controlled in a targeted manner? What are lessons learnt from experiences with the bioenergy promotion and how can they become effective for the bioeconomy?

iv) How can the demand for bio-based products and a balanced bioeconomy policy be increased to support the sustainable path transition?

v) What is the role of other large scale transition concepts such as the green economy?

Please note: The session language is German!

Bioeconomy – Opportunity for a sustainable society?

A3

Steffi Ober

Bundesgeschäftsstelle, Naturschutzbund Deutschland e. V. – NABU, Berlin, Germany

Contact: steffi.ober@nabu.de

The bioeconomy covers significantly different areas of life and infrastructures of a society – from eating to housing, heating and through to mobility. The word “Oikos” means intelligent economizing in the entire house. Today we would translate the entire house as a concept of planetary boundaries and intelligent economizing as green growth or degrowth. What this implies for research and innovation requires a societal and political discourse.

Challenges to sustainable biomass supply

A3

Iris Lewandowski

Department Biobased Products and Energy Crops, University of Hohenheim, Stuttgart, Germany

Contact: iris_lewandowski@uni-hohenheim.de

A substantive part of the bioeconomy builds on biomass as a resource base. In the envisioned "ideal" bioeconomy, biomass production will take ecological, social and health aspects into consideration and be internationally competitive. However, an analysis of the development of bioenergy has revealed that competing claims on biomass and agricultural land for its production are perceived as major obstacles to increasing sustainable biomass supply in the context of food security and environmental conservation. This contribution will summarize the status of defining sustainable biomass production and supply and discuss approaches for securing sustainable biomass in a growing bioeconomy.

Economic and legal challenges of the transition towards a sustainable wood-based bioeconomy

A3

Erik Gawel

Department of Economics, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: erik.gawel@ufz.de

Increasing the sustainability of economic processes and products as well as the use of sustainable resource inputs require a transition from the hitherto predominant fossil-based “throughput economy” towards a circular flow economy based on renewable resources. These complex economic and societal transition processes face significant uncertainties such as climate change, technological and economic development, sustainability risks, dynamic consumption patterns and policies and governance structures. Based on a three-step analysis of the legal and socio-economic challenges of a wood-based bioeconomy in Germany, we present recommendations for the design of future policies.

First, in a scenario analysis the key influencing factors are identified and their systemic roles for the future development of the wood-based bioeconomy in Germany are specified. Four scenarios were set-up to describe possible futures of the wood-based bioeconomy in Germany in 2050, allowing to adjust business strategies and policy instruments.

Second, the legal framework has to progressively support the advantages of the bioeconomy and simultaneously it has to avoid sustainability risks. Our analysis shows that a range of policies exist for the bioeconomy but that the overall effect is insufficient to initiate a path transition.

Third, in order to foster a sustainable future of a wood-based bioeconomy, governance structures are discussed, particularly “bioeconomy policies” that are needed to initiate a transition pathway. Based on the positive analysis of both current bioeconomy policies and policy demand by bioeconomy actors in Germany, we elaborate recommendations how to develop appropriate transition policies.

Sustainability evaluation tools as governance instruments in the bioeconomy

A3

Roland Essel

Sustainability Department, nova-Institut GmbH, Hürth, Germany

Contact: roland.essel@nova-institut.de

The bioeconomy is promising to introduce new chemicals, building-blocks and polymers with new functionalities and to develop new process technologies such as industrial biotechnology. It is supposed to help mitigating climate change through the substitution of petrochemicals by materials with lower GHG emissions. It could bring new business opportunities, investment and employment to rural areas and foster regional development. And finally, the whole utilisation of biomass could be optimised by new biorefinery concepts. But how do we assess the sustainability of the bioeconomy? This question will be addressed by presenting new evaluation tools as governance instruments.

Session B1: Microbial processes for recovery of critical metals from secondary resources

B1

Session coordinator and chairperson: ***Birgit Daus***

Department of Analytical Chemistry, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: birgit.daus@ufz.de

Metals are one of the key resources for the German “Energiewende”. There are different metals which are defined as critical in their use and availability like e.g. indium (In), germanium (Ge), tantalum (Ta), cobalt (Co), platinum group metals, and rare earths. They are also classified as ‘green minor metals’, which are the basis for cleaner technology innovation.

The use of secondary sources is one of the strategies to ensure the supply with these elements. Recent research results will be presented in the field of microbial leaching to recover such elements. The workshop will focus on the microbial processes of leaching and complexation (binding by metallophores) of metals and innovative methods of their analysis.

Reductive bioleaching for metal recovery from oxide ores

B1

Axel Schippers

Resource Geochemistry, Federal Institute for Geosciences and Natural Resources – BGR, Hannover, Germany

Contact: axel.schippers@bgr.de

In the past 50 years, biomining has developed into a vibrant and robust “green technology” and reductive bioleaching fits well into this objective as it has a reduced carbon footprint (the bacteria that carry out the processing fix CO_2, like green plants). To date, industrial scale biomining has been applied for dissolution of sulfide ores, but has not yet been used for metal extraction from oxides. The Ferredox process for reductive bioleaching of limonitic laterites for recovery of Ni, Co, Cu, Sc, Mn, Cr, Zn is validated in a laboratory scale proof-of-concept bioreactor. The main operating cost for this process is sulfur (for acid generation and food for the bacteria involved) and analysis of operational expenditure in using this approach for processing laterites has shown that it is economically feasible. Besides limonitic laterites oxidized ores comprise polymetallic deep-sea nodules and crusts, and supergene sulfide deposits. Existing technologies for the exploitation of such ores are costly and result in a large environmental footprint. Biomining seems to be a promissing geobiotechnology for processing oxidized ores and potentially waste.

Metallophores selectively bind metals

B1

Dirk Tischler

Institute of Biosciences, Technical University Bergakademie Freiberg, Freiberg, Germany

Contact: dirk-tischler@email.de

Metallophores are low-molecular-weight compounds produced by microorganisms for scavenging iron and other metal ions from the environment. Since these compounds had been mostly described for their iron binding capacity, they are often designated as siderophores as well. They possess a high affinity and selectivity for ferric iron (Kf >10 30). Some of them are able to effectively bind other metals (e.g. Ga, V, Mo) as well. In order to identify metallophores, which are able to bind strategically important metals like Gallium and Vanadium we screened numerous soil bacteria and fungi for metallophore production and metal-affinity using chrome azurol S (CAS) as the detection reagent. CAS agar effectively showed microorganisms which are able to produce and excrete large amounts of metallophores. But many bacteria grew very poor or failed to grow on CAS agar. Thus we used an alternative growth medium and a liquid CAS assay variant. This assay was optimized regarding to the used buffer system, different metal ions and their concentrations as well as an optimal cultivation medium in order to have an applicative and useful screening method for different types of microorganisms. The producer strains are investigated in more detail and metallophores obtained for their applicability in metal-binding for purposes as extraction and sensors.

Acknowledgement: This research was supported by the Federal Ministry of Education and Research (BakSolEx #033R147)

Correlative microscopy for analysing dissolution of minerals and electron transfer processes as a key step for development of bio-mining concepts

B1

Niculina Musat

Department of Isotope Biogeochemistry, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: niculina.musat@ufz.de

Metal-biomining processes based on the bioleaching activity of microbes deals with the extraction of metals from mineral resources not accessible to conventional mining. Microbes such as bacteria may convert metal compounds into their water-soluble forms. Since, first metal extractions in the presence of iron-oxidizing microorganisms, many studies have focused on these organisms and their role in bioleaching. However, a great variety of microbes were recently identified in leaching environments by molecular methods such as 16S rRNA sequencing, fluorescence in situ hybridization, immunological techniques and isolation. At present there is very little known about the in situ abundance, metabolic activity, the role of such communities in bioleaching and their potential use in biomining. In the present talk we will tackle the following questions: i) Who are the in situ key players of microbial communities in terrestrial habitats such as mine tailings and waste dumps (Davidschacht and Theissenschlamm sites)? ii) What are their in situ function and metabolic rates with respect to C and N uptake? iii) What is the main mechanism of bioleaching in

these environments (cell attachment to minerals vs electron carriers e.g. ferrous iron)? iv) How are microorganisms attaching to the minerals? v) What are the main factors influencing bioleaching and metal recovery (e.g. pH, temperature, microbial community structure, particle size, nutrient availability)? Using a combination of high resolution correlative microscopy and chemical imaging e.g. fluorescence microscopy, nano-scale secondary ion mass spectrometry (nanoSIMS), confocal RAMAN spectroscopy, scanning electron and helium ion microscopy (SEM/HIM) we aim at solving nano-scale intercellular metabolic interactions and those between cells and minerals. In addition to environmental communities, we used *Shewanella* as model organism to understand biofilm formation and colonization of metals as well as electron transfer processes.

Speciation analysis – A tool for identification and quantification of metal compounds

B1

Birgit Daus

Department of Analytical Chemistry, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: birgit.daus@ufz.de

The analysis of the specific form of an element (chemical species) is called speciation analysis. In recent years the analysis of species has become a main issue in environmental science. The chemical species has not only an influence on the environmental behaviour of an element, but also on the (bio-)leaching procedure in a technical scale. A usual approach of speciation analysis is to couple a chromatographic separation technique (e.g. HPLC or GC) to an element specific, sensitive detector (e.g. ICP-MS). The redox state of an element (e.g. Sb(III)/Sb(V)) or a specific compound (methylated species or complexes) can be analysed in a liquid sample in this way.

The challenges and possibilities of speciation analysis are demonstrated with some examples (antimony, germanium, and arsenic species) of our recent research.

Sessions B2 and B3: Industrial biotechnology concepts making use of renewable resources

B2 + B3

Session coordinators and chairpersons: [1] ***Bruno Bühler,*** [2] ***Sabine Kleinsteuber***

[1] Department of Solar Materials, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

[2] Department of Environmental Microbiology, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: [1] bruno.buehler@ufz.de, [2] sabine.kleinsteuber@ufz.de

This double session deals with biotechnological concepts allowing the use of renewable resources for material and energy production. Thereby, resources include sugars and plant oils (first generation), cellulose and lignin (second generation), as well as carbon dioxide and waste products in the sense of a circular economy as it is aimed at in future bioeconomy concepts. Biological and technical challenges and approaches based on hetero- as well as autotrophic organisms will be discussed.

The products themselves will also be a topic. Biotechnology-derived products have application potential in different sectors of industry and include energy carriers, bulk-, fine-, and specialty chemicals, and polymers as well as active substances and thus the pharma sector. The latter is less resource-intensive, but profits from novel active substances and their building blocks, which only can be produced via biotechnological means and respective resource utilization.

Thus, beside the dimensions economy (production of energy, chemicals, and pharmaceuticals) and environment / land use, the dimension society / health also comes into play – quite in the sense of an integrated bioeconomy.

Biosyngas production and its advanced chemical and biochemical use: I. Syngas production from biomass

B2

Nicolaus Dahmen

Institute of Catalysis Research and Technology, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

Contact: nicolaus.dahmen@kit.edu

The new bioliq® pilot plant at the KIT covers the complete process chain required for producing synthetic fuels and chemicals from dry lignocellulosic biomass. For energy densification of the biomass, fast pyrolysis is applied as pre-treatment step. The liquid pyrolysis oil and solid char obtained are further processed in the entrained flow-gasifier to tar-free, low-methane raw synthesis gas. Prior to chemically catalysed fuel synthesis a multistep cleaning of raw synthesis gases is performed by a hot gas cleaning system: particles, alkaline salts, and undesired trace gas components are removed to avoid catalyst poisoning during chemical catalysed fuel synthesis. Today, gasoline is produce in the pilot plant. However, R&D is dedicated to develop advanced high performance biofuel components such as oxymethylene ethers.

Biosyngas production and its advanced chemical and biochemical use: II. Microbial production of platform chemicals from syngas

B2

Anke Neumann

Institute of Process Engineering in Life Science, Karlsruhe Institute of Technology (KIT, Karlsruhe, Germany

Contact: anke.neumann@kit.edu

Acetogenic bacteria are able to ferment syngas to a variety of organic acids and alcohols. In contrast to the chemical catalysts, these biological catalysts can process a broad range of syngas compositions and deal with impurities like sulphur or nitrogen compounds or CO_2. To assess industrial large scale applicability of these strains it will be necessary to determine their performances with crude syngas, as each purification step will decrease the economy of the process. Another major challenge of this so called syngas fermentation is the poor solubility of CO and H_2 in the fermentation broth. To overcome this limitation one could increase the kla-value for better mass transfer into the broth or increase the pressure in the bioreactor to obtain better solubility of the gases. On the other hand, almost complete substrate usage is enabled by recycling the off gas. This also leads to enrichment of not utilized compounds of the crude syngas in the fermentation broth. To evaluate the impact of major impurities of crude syngas and the impact of high kla-values a setup of multiple 2 L bioreactors with product analysis and online gas measurement was developed in our lab. With this setup it is possible to investigate kla-values and substrate usage of different stirrer set-ups and aeration modes. Also the impact of the nitrogen impurities of syngas, NH_3 and HCN, on growth and product formation was evaluated.

Microbial resources mining for primary microbial electrochemical technologies

B2

Christin Koch

Department of Environmental Microbiology, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: christin.koch@ufz.de

Primary microbial electrochemical technologies (METs) interface microorganisms and electrodes and are based on the functional connection of the microbial metabolism and an electric current flow through microbial extracellular electron transfer. They can be applied for the treatment of waste streams of different chemical composition as well as complexity.

Highly diverse electroactive microbial communities establish from complex waste sources and can successfully treat it while more defined substrates result in highly specialized microbial communities of low diversity. The organization of electroactive microbial communities in flexible food webs is only little investigated and the specific interactions and structure-function relationships including functional redundancy are hardly understood.

A better understanding of the ecological niche of electroactive microorganisms will help to improve their functional performance and widen the application of METs to different waste resources.

Malic acid production from glycerol with *Ustilago trichophora*

B2

Nick Wierckx

Institute of Applied Microbiology, RWTH Aachen University, Aachen, Germany

Contact: nick.wierckx@rwth-aachen.de

The rising production of biodiesel is accompanied by the production of a huge amount of glycerol, which is, with 10 %(w/v), the main low-value by-product. Hence, the valorization of this large waste stream is considered a high priority in order to make the overall biodiesel refinery economically and ecologically feasible. One approach is the microbial conversion of crude glycerol to value-added chemicals.

To this end, we screened 76 *Ustilaginaceae* for conversion of glycerol to organic acids. This fungal family is known to produce organic acids naturally at high titers, rates and yields (1). *Ustilago trichophora* was found to efficiently produce malic acid from glycerol naturally with little by-products. Malic acid is a promising bio-based chemical, currently mainly used as acidulant in foods and beverages. However, it also has a great potential as bio-based building block with a wide range of applications including polymers, pharmaceuticals and solvents (2). The glycerol uptake rate of *U. trichophora* is relatively low. By evolutionary engineering, the growth and production rates were increased by 2.5-fold and 6.6-fold, respectively. For economically feasible production of malic acid that can compete with existing production processes, high titers, yields and rates are required. Further medium and fermentation process optimization increased the overall production rate to 0.74 g/l/h with a maximum production rate of 1.5 g/l/h reaching a titer of 195 g/l. This titer is the highest reported for the microbial production of malic acid so far, making *U. trichophora* a promising microbial production host for the valorization of biodiesel-associated glycerol.

References:

(1) Geiser E, Wiebach V, Wierckx N, Blank L.M. (2014). Prospecting the biodiversity of the fungal family Ustilaginaceae for the production of value-added chemicals. Fungal Biology and Biotechnology. 1:2.

(2) Werpy, T., Petersen, G., et al. (2004). Top value added chemicals from biomass. Volume 1

Lignin biorefinery: Novel enzymes for selective ether bond cleavage

B2

Anett Schallmey

Institute for Biochemistry, Biotechnology and Bioinformatics, Technische Universität Braunschweig, Braunschweig, Germany

Contact: a.schallmey@tu-braunschweig.de

Biomass degrading enzymes attract significant research interest for their application in the synthesis of chemicals and biofuels from renewable feedstocks. In that respect, lignin, a heterogeneous aromatic polymer present in lignocellulose, could serve as a renewable source of aromatic platform chemicals. We have identified a number of novel beta-etherases and glutathione lyases with potential applicability in lignin valorization [1-3]. These glutathione (GSH)-dependent enzymes selectively catalyze the reductive cleavage of beta-

O-4 arylether bonds present in lignin. Biochemical and biocatalytic characterization of the novel enzymes with various model substrates revealed a remarkably high enantioselectivity in ether bond cleavage for all tested beta-etherases. In contrast, enanioselectivities of glutathione lyases varied significantly among the tested enzymes [3]. Using a fluorescently-labelled synthetic lignin as substrate, the enzymes' activity on polymeric substrates was also proven [2]. Some of the enzymes were even found to exhibit increased thermostability, thus, providing promising hints for further practical applications. Meanwhile, crystal structures of representative members of both enzyme groups, beta-etherases and glutathione lyases, are available enabling a deeper understanding of structure-function relationships as well as future optimization of enzyme characteristics by protein engineering.

References:

[1] P. Picart, P. Dominguez de Maria, A. Schallmey (2015) Front Microbiol, 6, 916

[2] P. Picart, C. Müller, J. Mottweiler, L. Wiermans, C. Bolm, P. Dominguez de Maria, A. Schallmey (2014) ChemSusChem, 7, 3164 – 3171

[3] P. Picart, M. Sevenich, P. Dominguez de Maria, A. Schallmey (2015) Green Chem, 17, 4931–4940

High value from specialized plant natural products: From source to biocatalytic conversion

B3

Ludger Wessjohann

Bioorganic Chemistry, Leibniz Institute of Plant Biochemistry (IPB), Halle (Saale), Germany

Contact: wessjohann@ipb-halle.de

The standard for the accession of high value products from plants is extraction from dried crude material, often followed by expensive purification processes. For many products, sufficient natural material is not available for a reasonable price, or not available at all. In these cases biotransformations starting from readily available, cheap natural material can be used to produce the high value products. Usually, many steps in form of biocatalytic cascades are required, commonly requiring side-streams e.g. for co-factor (re-)generation. The ideal pathways often do not follow the natural ones, and often have to be developed de novo with new enzymes or (rationally) adapted ones. The enzymatic cascades can be utilized in vitro, or in the sense of synthetic biology also in vivo. In both cases the proper adjustment of enzyme and reaction properties to be functional in the production system is a crucial and limiting factor.

We will present such enzymatic cascade systems for the syntheses of phenylpropanoid plant natural products for the flavour industry.

Biotechnological concepts for chemical and polymer production in the context of bioeconomy

B3

Jochen Schmid

Chemistry of Biogenic Resources, Technische Universität München, Munich, Germany

Contact: j.schmid@tum.de

The talk will deal with novel biorefinery concepts to realize a biobased economy. Conversion of biomass into chemical monomers and polymers is in the focus.

A crucial difference between plant biomass and mineral oil lies in the quantity and locality of its availability. While mineral oil and its primary products can be transported through pipelines in great quantities without any problems and at little cost, plant products accumulate in smaller amounts across large areas. Transport across long distances is energetically expensive and does not pay off. The advantages of biotechnological processes are that they require comparatively simple facilities. This fact enables smaller industries to operate locally where the biomass accumulates e.g. as agricultural leftovers. We are working on different biorefinery concepts which will be realized in small- to mid-scale with modular set up, to react on changing substrate conditions as well as market demand for products.

An important technical issue is the purification of the products from diluted aqueous solutions that come when working with biomass and microbes. One solution here is the production of gases from intermediates. Outgassing from fermentation broth with following gas purification is much more greener, easier and energy saving than the separation of different liquid products. Another solution is to circumvent product-related toxicity on microbial cells by use of pure enzyme cascades. There are promising results of strain improvement for efficient gas fermentations and highly efficient enzyme cascades towards fine as well as bulk chemicals.

Another challenge is the direct production of green polymers such as microbial exopolysaccharides, which represent a valuable source of biogenic and biodegradable polymers with high functionalities. The use of genetic and metabolic engineering enables production of tailor made exopolysaccharides to be applied in specific technical applications of a biobased industry.

Synechocystis biofilms as solar driven biocatalysts

B3

Katja Bühler

Department of Solar Materials, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: katja.buehler@ufz.de

In the course of the debate regarding fossil carbon and energy, a lot of research is invested into the development of biological catalysts fuelled by sunlight, CO_2 and H_2O. Besides focussing on the biorefinery approach and maximizing biomass, photoautotrophic microbes are harnessed for directly producing a whole bunch of interesting compounds. However, low activities, low stabilities, and slow growth are problems these approaches are facing. Here we report on utilizing a biofilm based concept to realize a truly continuous bioprocess for the synthesis of 1,2-propane diol, as these microbial communities feature extraordinary robustness and permanent regeneration [1]. First fermentations have been conducted

yielding final product titers of 4 mM 1,2-propane diol. Strikingly, the production of the 1,2-propane diol seemed to be clearly coupled to the stationary phase of the organism, as production started when cell growth ceased. Our findings indicate an uncoupling from cell growth and 1,2-propanediol synthesis. In addition, biofilms of *Synechocystis* sp. PCC 6803 seemed to stall growth at an optimal biofilm thickness of about 100 µm [2]. Thereby the reaction format of applying a phototroph as a catalytic biofilm for the generation of value added compounds fuelled by sunlight and CO_2 seem to be a perfect match for continuous solar driven catalysis.

References:

[1] B. Halan et al, Trends Biotechnol. (2012) 30:453

[2] C. David et al, J Ind Microb Biotech (2015) 42:1083

Biocatalytic H_2 production under aerobic conditions: Challenges and opportunities

B3

Oliver Lenz

Department of Chemistry / Biophysical Chemistry, Technische Universität Berlin, Berlin, Germany

Contact: oliver.lenz@tu-berlin.de

Hydrogenases are nature's catalysts designed for rapid and reversible oxidation of H_2 into protons and electrons. Both the formation and consumption of H_2 are catalysed with conversion rates of up to 10,000 molecules per second. All hydrogenases known so far utilise abundant transition metals such as nickel and iron for catalysis, which is in sharp contrast to man-made H^+/H_2-cycling catalysts that predominantly rely on the rare precious metal platinum. This situation currently boosts research on biological and bioinspired catalysts. Since transition metals are intrinsically susceptible to dioxygen, the catalytic centers of most hydrogenases become inactivated or even destroyed upon interaction with O_2. This property hampers the application of these biocatalysts in, e. g., light-driven H_2 production by coupling hydrogenase with oxygenic photosynthesis.

However, some microorganisms are able to gain energy from the controlled combustion of H_2 with dioxygen. This process is mediated by so-called "oxygen-tolerant" [NiFe]-hydrogenases. In this context, O_2 tolerance is defined as sustained H^+/H_2 cycling in presence of O_2. This talk will briefly introduce the fundamental aspects of how certain [NiFe]-hydrogenases cope with the detrimental effects of O_2. The second part is dedicated to the biotechnological application of O_2-tolerant hydrogenases, including achievements and challenges of solar-driven H_2 production with cellular systems.

References:

Lenz, O., L. Lauterbach, S. Frielingsdorf & B. Friedrich. Oxygen-tolerant hydrogenases and their biotechnological potential. In Biohydrogen (Rögner, M., ed), chapter 4, pp.61-96, De Gruyter, Berlin (2015).

Fritsch, J., O. Lenz & B. Friedrich. Structure, function and biosynthesis of O_2-tolerant hydrogenases. Nat. Rev. Microbiol. 11:106-114 (2013).

Friedrich, B., J. Fritsch & O. Lenz. Oxygen-tolerant hydrogenases in hydrogen-based technologies. Curr. Opin. Biotechnol. 22:358-364 (2011).

Session C1: High shares of volatile renewables in the electricity mix: How to activate flexibility options in the power supply system?

Session coordinator and chairperson: ***Klaas Korte***

Department of Economics, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: klaas.korte@ufz.de

In the frame of the 'Energiewende' the share of volatile renewables such as wind and solar power is expected to become dominating in the German electricity mix in the future. However, power demand seems to be not flexible enough to cope with future supply fluctuations, at least in the short run, be it for technical or economic reasons. Hence, there is need for other flexibility options to be applied to keep the power grid stable. One technical solution for this could be power storage which is still a very costly option. Another solution is to make power supply "system friendlier", that is to design the feed-in pattern in such a way it matches better with demand.

Besides technological options such as the more flexible employment of biomass and biogas plants, the spatial distribution of volatile generation units offers potential for the variation of feed-in. To what extent these different options are employed depends in great measure on the governance framework, e.g., the remuneration scheme for renewables or the general power market design. In summer 2015 the German government published a "white paper" for the future electricity market design presenting concrete measures for adjusting the electricity market. The white paper clearly favours a market approach for incentivising flexibility and securing supply in the future. Eventually, security of supply is just one goal of energy policy and, thus, support of demand orientation of supply needs to be in line with the other objectives, in particular with the goal of an environmentally sound energy supply.

The aim of this session is to discuss what options are available for higher demand orientation of renewable electricity generation, if and how they are compatible with other energy policy objectives and what implications can be derived for the design of the government framework. Particularly, the question arises whether the white paper points towards the right direction and if additional measures need to be applied.

Please note:

This session is an IP-internal working session. However, guests are welcome.

The session language is German!

Session C2: Renewable energy siting and new conflict lines

C2

Session coordinators and chairpersons: [1] ***Matthias Groß,*** [2] ***Nona Schulte-Römer***

[1,2] Department of Urban and Environmental Sociology, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: [1] matthias.gross@ufz.de, [2] nona.schulte-roemer@ufz.de

This session explores new potential conflict lines in the context of renewable energy site selections. It centres on the question of how these conflicts evolve as the German Energiewende continues to develop and how they relate to parallel developments. Drawing on empirical examples, the discussion will focus on a variety of topics, including but not limited to the following:

Energy-related protest: How do civic protests against energy siting change and differ as renewable energy production becomes more and more common and widespread? We are also interested in relationships between old and new energy protests: How are the renewed protests against open cast mining or the selection of permanent disposal sites for nuclear waste linked to renewable energy issues and vice versa?

Ownership structures: Recent movements to re-municipalize energy utilities raise the question of how public and private ownership affects renewable energy-related conflicts. In other words, can we find evidence that the establishment of renewable energy infrastructures is either facilitated or slowed down by remunicipalisation? Can we transfer our findings to conflicts around renewables and site selection on the countryside?

New spatial conflict lines: Sun and wind may appear as sources of infinite energy, the spaces for their exploration are not. The conflict potential in this respect is vast and well-known. However, less apparent are conflicts that can arise when renewable energy siting interferes spatially with already existing energy production sites. We are interested in cases and concepts to settle or prevent such conflicts between present and future suppliers of the renewable energy mix.

In this session, the presenters will cover different areas offering concrete examples followed by an open panel discussion.

Communities and space-related conflicts over wind farms: Insights from the UK and Denmark

C2

David Rudolph

Wind Energy, Technical University of Denmark, Roskilde, Denmark

Contact: dpru@dtu.dk

Technological advancements in renewables, in particular wind energy, have transformed wind farms into critical infrastructures that evoke an ideological battle between small traditional co-operative and large-scale commercial projects. While locally-rooted wind farm projects are supposed to feature an inherent local acceptability due to local involvement and revenues, corporate developers of commercial projects have to gain public acceptance. The paper will present a synopsis of empirical findings from research projects conducted in the

UK and Denmark in order to illuminate the contentious interplay between community engagement, ownership, benefits and the siting of offshore and onshore wind farms in different institutional settings.

By applying a developer's perspective it will be highlighted that wind farm developers are not a homogenous group, but consist of different actors of various constellations, such as energy companies, regional utilities, associations, citizens or private landowners, with different approaches to the development of wind farms. While the delivery of community benefits from and local co-ownership of commercial projects in the UK usually take place on a voluntary basis, efforts of large developers have led to a wide range of benefit models for onshore and offshore wind farms that give evidence of good practice beyond legal compliance. In contrast, although the Danish renewable Energy Act comprises obligatory but confined measures to increase acceptance through community ownership and benefit, it will be shown that developers increasingly face challenges of finding adequate sites and getting access to land for large onshore projects in the first place, which has resulted in 'new' practices to avoid spatial conflicts.

The paper concludes with some preliminary thoughts on the implications of a new support scheme for renewables based on a tendering/auction system imposed by the EU and currently being implemented in the member states.

"Energiewende" and citizens' protest: Local conflicts, actors and dynamics

C2

Julia Zilles

Institut für Demokratieforschung, University of Göttingen, Göttingen, Germany

Contact: julia.zilles@demokratie-goettingen.de

The German "Energiewende" is considered a role model for transforming the energy landscape in Europe and the world. Meanwhile, over 30 percent of the electricity generation is done by renewable energy. The effects of this transformation are, literally, visible all over the country: Wind farms on- and offshore, new overhead power cables across the country, photovoltaic systems on roofs and fields as well as biogas plants. While the "Energiewende" is a national and moreover global topic, the actual conflicts are taking place at the local level. It is here where people protest against the construction of overhead power cables, the installation of huge wind power plants and the use of Hydraulic Fracturing. Most recent studies have exclusively focused on the participants of protest movements. In our project, we expanded the focus and analysed all actors involved in these conflicts, such as local politicians and authorities, companies, protest groups, as well as those citizens who decided not to join the protests. Our data material is gathered from four case studies on conflicts over large infrastructure projects in the context of the German "Energiewende". All conflicts took place in small administrative entities (Landkreis). We conducted about 40 guided interviews with all actors involved and, moreover, organized six focus groups with citizens that did not participate in the protests. Based on this broad empirical base we can describe the specific point of view of all players on the conflicts and their perceptions of the opposing side. We analyse the dynamics taking place in contact between the different actors. How do companies deal with local protest? What is the relationship between local politicians and protest activists? What's the impact of local media? Are protests an expression of declining

levels of trust in a society in which large infrastructure projects are more and more unlikely to realize? Or are they a starting point of democratic innovation?

Us, and them: Lines of conflict, identities and socially constructed spaces in the context of siting decisions for wind energy developments

Markus Leibenath

Research Areas „Landscape Change and Management“, Leibniz Institute of Ecological Urban and Regional Development, Dresden, Germany

Contact: m.leibenath@ioer.de

There is much research on conflicts revolving around the issue of finding sites for wind turbines, with empirical evidence from many countries. Some authors point to the salience of spatially referenced identities, which have also been conceptualised as place attachment. Furthermore, scholars from social and cultural geography have analysed the social construction of spaces from various theoretic angles.

The aim of this contribution is to present two types of linkages between collective identities and socially constructed spaces in the context of siting-decisions for wind energy developments. The empirical findings are taken from two case studies in Germany: one in the town of Wolfhagen in northern Hesse and the other one in the Saxon region Upper Elbe Val-ley/East Ore Mountains.

The analytical framework is rooted in poststructuralist discourse theory, epitomised by authors such as Laclau, Mouffe, Howarth and others, as well as in Foucault’s notions of subjectivity and rationality as components of his governmentality perspective. In methodical terms, the case studies rely on newspaper analyses, semi-structured interviews and partly also on participant observation.

Notwithstanding the distinct institutional settings of the two cases, it is interesting to see that the Wolfhagen wind energy controversy led to a sharp division of the local community and spurred the emergence of two antagonistic identities. Each of them is linked to specific constructions of the Roedeser Berg, the (then) proposed site of a wind farm. By contrast, in the Saxon region, a powerful discourse evolved in which the identity of the affected villages was constructed in sharp antagonism to the nearby state capital of Dresden.

The paper concludes with some thoughts, firstly, on the interrelations between local discourses on wind energy and the wider discursive environment in which they are embedded and, secondly, on possibilities of influencing such discourses strategically.

Energy controversy theorised in the context of socio-technical change: The case of fracking for shale gas

Paul Upham[1], Aleksandra Lis[2], Hauke Riesch[3] and Piotr Stankiewicz[4]

[1] Institute for Environmental and Sustainability Communication (INFU), Leuphana University Lüneburg, Lüneburg, Germany

[2] Department of Cultural Anthropology, Adam Mickiewicz University, Poznań, Poland

[3] Department of Sociology and Communications, Brunel University, London, United Kingdom

[4] Institute of Sociology, Nicolaus Copernicus University, Toruń, Poland

Contact: [1] upham@leuphana.de

While sociologists of science and technology have long understood technology acceptance as a process of social embedding, the psycho-social processes involved have received relatively little attention in the socio-technical transitions literature. Similarly, energy technology controversy, particularly public objection, has rarely been theorised within the theoretical context of socio-technical change. Here we illustrate the value of Moscovici's social representations theory for its contribution to the most commonly used model of socio-technical change, the multi-level perspective (MLP). Using fracking-derived shale gas as a technology case study and newspaper representations of the technology in Poland, Germany and the UK as data, we address and illustrate connections between the processes of anchoring and objectification that are central to social representations theory and the socio-technical dynamics observed. In so doing, we set out an approach for further work on agency in the MLP and socio-technical change processes generally, informed by a social psychological approach that aligns with a structuration-based approach to social agency and change.

Session C3: Exploitation of subsurface resources for thermal and substantial energy storage within the context of the transformation of the energy system

Session coordinators and chairpersons: ***Sebastian Bauer[1], Uwe Jens Görke[2], Olaf Kolditz[3]***

[1] Institute of Geoscience, Kiel University, Kiel, Germany

[2,3] Department Environmental Informatics, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: [1] sebastian.bauer@gpi.uni-kiel.de, [2] uwe-jens.goerke@ufz.de, [3] olaf.kolditz@ufz.de

To overcome the natural temporal fluctuations inherent in the energy production based on certain renewable sources (e.g., wind, photovoltaics) is a requirement for the transition of the energy system towards renewable resources. Energy storage provides a solution to the time shift between energy production and demand. Storage options for renewable energies include the conversion to and storage of secondary energy carriers like compressed air, hydrogen and methane as well as heat, and the geological subsurface holds a large potential of storage capacities, e.g. in salt caverns and porous formations. In the ANGUS+ project (www.angusplus.de) the potentials and implications of energy storage in the geological subsurface are investigated.

Within the project, storage formations are characterized by physical and chemical properties, and the processes induced by energy storage applications are parameterized based on literature studies and laboratory experiments. This new parameter database feeds numerical modelling tools developed and implemented within the project to simulate the coupled thermal, hydraulic, mechanical, chemical and microbiological processes induced by subsurface energy storage applications and their interaction with other types of use of the geological subsurface. Based on the enhanced process understanding in the geological subsurface, virtual scenarios of gas storage in salt caverns and deep porous formations as well as scenarios of heat storage in the shallow and moderately deep subsurface are developed. The numerical simulation of energy storage operations helps predicting impacts on protected resources and deducing appropriate monitoring methods.

Contributions to this session address the analysis of several storage options such as gas storage in deep aquifers as well as in salt caverns, and heat storage in shallow geological sites. In addition, aspects of integrated 3D visualization of the considered geotechnical systems will be discussed as well as first concepts of subsurface spatial planning.

Quantifying induced effects of subsurface renewable energy storage – The ANGUS+ project

C3

***Sebastian Bauer*[1], *Andreas Dahmke*[1], *Wolf Tilmann Pfeiffer*[1], *Bo Wang*[1], *Jens-Olaf Delfs*[1], *Anke Boockmeyer*[1], *Steffi Popp*[1], *Dedong Li*[1], *Christof Beyer*[1]**

[1] Applied Geosciences, Kiel University, Kiel, Germany

Contact: sebastian.bauer@gpi.uni-kiel.de

New methods and technologies for energy storage are required for the transition to renewable energy sources. Subsurface energy storage systems such as salt caverns or porous formations offer the possibility of hosting large amounts of energy or substance. When employing these systems, an adequate system and process understanding is required in order to assess the feasibility of the individual storage option at the respective site and to predict the complex and interacting effects induced. This understanding is the basis for assessing the potential as well as the risks connected with a sustainable usage of these storage options, especially when considering possible mutual influences.

For achieving this aim, in this work synthetic scenarios for the use of the geological underground as an energy storage system are developed and parameterized. The scenarios are designed to represent typical conditions in North Germany. The types of subsurface use investigated here include gas storage and heat storage in porous formations. The scenarios are numerically simulated and interpreted with regard to risk analysis and effect forecasting. For this, the numerical simulators Eclipse and OpenGeoSys are used. The latter is enhanced to include the required coupled hydraulic, thermal, geomechanical and geochemical processes. Using the simulated and interpreted scenarios, the induced effects are quantified individually and monitoring concepts for observing these effects are derived.

This presentation will detail the general investigation concept used and analyse the parameter availability for this type of model applications. Then the process implementation and numerical methods required and applied for simulating the induced effects of subsurface storage are detailed and explained. Application examples show the developed methods and quantify induced effects and storage sizes for the typical settings parameterized.

Thermo-mechanical modelling of cyclic gas storage applications in salt caverns

C3

***Norbert Böttcher*[1], *Thomas Nagel*[2], *Uwe-Jens Görke*[2], *Olaf Kolditz*[2]**

[1] Geotechnische Sicherheitsnachweise, Federal Institute for Geosciences and Natural Resources – BGR, Hannover, Germany

[2] Department of Environmental Informatics, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: norbert.boettcher@bgr.de

Due to the growing importance of renewable energy sources it becomes more and more necessary to investigate energy storage potentials. One major way to store energy is the power-to-gas concept. Excessive electrical energy can be used either to produce hydrogen or methane by electrolysis or methanation or to compress air, respectively. Those produced

gases can then be stored in artificial salt caverns, which are constructed in large salt formations by solution mining.

In combination with renewable energy sources, the power-to-gas concept is subjected to fluctuations. Compression and expansion of the storage gases lead to temperature differences within the salt rock. The variations can advance several metres into the host rock, influencing its material behaviour, inducing thermal stresses and altering the creep response.

To investigate the temperature influence on the cavern capacity, we have developed a numerical model to simulate the thermo-mechanical behaviour of salt caverns during cyclic gas storage. The model considers the thermodynamic behaviour of the stored gases as well as the heat transport and the temperature dependent material properties of the host rock. Therefore, we utilized well-known constitutive thermo-visco-plastic material models, implemented into the open source-scientific software OpenGeoSys. Both thermal and mechanical processes are solved using a finite element approach, connected via a staggered coupling scheme. The model allows the assessment of the structural safety as well as the convergence of the salt caverns.

Quantification of storage capacities and withdrawal rates of high-temperature heat storages in the subsurface

C3

***Anke Boockmeyer*[1], *Sebastian Bauer*[1], *Christof Beyer*[1], *Meike Hintze*[1], *Kerstin Meier zu Beerentrup*[1]**

[1] Applied Geosciences, Kiel University, Kiel, Germany

Contact: anke.boockmeyer@gpi.uni-kiel.de

Thermal energy storage is one option of storing energy from renewable sources to overcome seasonal disparities between heat production and heat demand. In the subsurface, heat can either be stored in borehole thermal energy storage sites (BTES) through borehole heat exchangers or in aquifer thermal energy storage sites (ATES) through open well doublets. Using high temperatures of up to 90°C allows to achieve high temperature gradients and high energy densities and thus large storage capacities at high storage rates.

This works investigates the resulting induced thermal and hydraulic effects and quantifies storage dimensions, capacities as well as storage and recovery rates by numerical scenario simulations.

Results show that heat recovery of a BTES site mainly depends on the number of heat exchangers used as well as on the thermal conductivity and hydraulic permeability of the storage formation. Recovery rates increase with increasing heat exchanger number and with increasing thermal conductivity. In contrast, high permeabilities in combination with high operation temperatures may induce convective flow and heat transport in the storage formation, which may cause efficiency decrease and larger regions of thermal impact.

Using ATES, heat is stored by advective heat transport which is mainly controlled by the pumping rates of the well doublet and the storage formation hydraulic permeability. At high permeabilities and temperatures, induced convection also occurs in these systems, which reduces storage efficiency and enhances heat emissions to neighbouring formations. Higher permeabilites hence lead to an increase of the region of thermal impact and thus to increased heat losses with lower recovery rates.

Impact factors on the long-term economic efficiency and environmental sustainability of borehole heat exchanger systems for the use of shallow geothermal resources

***Haibing Shao*[1], *Philipp Hein*[1], *Sophie Schelenz*[2], *Thomas Vienken*[2], *Olaf Kolditz*[1]**

[1] Department of Environmental Informatics, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

[2] Department of Monitoring and Exploration Technologies, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: haibing.shao@ufz.de

In recent years, Borehole Heat Exchanger (BHE) based Ground Source Heat Pump (GSHP) systems have been increasingly applied around the globe, providing heating and cooling to buildings. Some GSHP systems are experiencing a gradual decrease of BHE outflow temperatures and thus finally be shut down due to low temperature protection. In this work, a comprehensive numerical model was established, to quantitatively prognoses the flow and heat transport processes in and around a BHE, together with the dynamic change of heat pump efficiency. Model parameters, including the local geothermal gradient, soil temperature and surface weather conditions were adopted for simulation over 30 years. It is found that the recovery of subsurface temperature only accounts for about 89% of the energy extracted after the first year of operation. Yet, over the following years, the outflow and soil temperature will gradually drop until reaching a quasi-steady-state. Because of a stronger thermal gradient around the BHE, more thermal energy will be conducted from the neighbouring soil and balances the amount of energy extracted. It is also found that lateral groundwater flow and applying BHE for cooling will be beneficial to the recovery process, along with the efficiency improvement of the heat pump. Among all influencing parameters, the soil heat capacity and thermal conductivity are considered to have minor impact on the long-term sustainability, while the application of thermally enhanced grout material will always be financially beneficiary. In contrast, it is very likely that undersized systems and improper grouting are the causes of strong system degradation. Therefore it is especially important to consider soil thermal conductivity as a key parameter for the determination of BHE installation length. Hence, a detailed knowledge about the geological subsurface and hydrogeological regime can greatly contribute towards a sustainable intensive thermal use of the shallow subsurface.

Data integration workflow and interactive visualization of potential salt cavern regions

C3

***Lars Bilke*[1], *Norbert Böttcher*[2], *Michael Nolde*[3], *Malte Schwanebeck*[3], *Rainer Duttmann*[3], *Olaf Kolditz*[1]**

[1] Department of Environmental Informatics, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

[2] Geotechnische Sicherheitsnachweise, Federal Institute for Geosciences and Natural Resources – BRG, Hannover, Germany

[3] Department of Geography, Kiel University, Kiel, Germany

Contact: lars.bilke@ufz.de

Extension of renewable energy in Germany requires the identification of suitable energy storage sites, e.g. for compressed gas in the underground. Selection of such sites depends on a variety of indices from geological data (e.g. rock layers, salt caverns, faults) and energy related surface data (e.g. energy infrastructure, location of power plants) as well as legal obligations (e.g. protected areas).

A GIS-based 3D online planning tool for interactively selecting sites for underground energy storage is developed. Users can intuitively change index parameters while potential storage sites are shown immediately and updated according the users requirements. From then on these generated 3D data sets can be converted to more sophisticated visualization applications as well as virtual reality environments which provide a useful tool to explore and analyze heterogeneous and complex data sets to help in process understanding and to communicate scientific findings to other researchers or the interested public (knowledge transfer / acceptance of storage systems).

An integrated visualization of the ANGUS+ project area with data from a variety of sources has therefore been developed. We focused on the structure model of Schleswig-Holstein showing geological layer and salt formations (from geophysical measurements), possible salt cavern structures (generated by stochastic methods) and regions and simulated gas storage cyclic loading scenarios showing temperature and stress fields. The user can interactively navigate, move to predefined points of interest, toggle through multiple storage scenarios and control the presentation of time-dependent data sets.

Legal options to deal with diverging claims concerning use of underground space

Jana Bovet

Department of Environmental and Planning Law, Helmholtz Centre for Environmental Research – UFZ, Leipzig, Germany

Contact: jana.bovet@ufz.de

The use of the geological underground, the area below the surface to depths of several kilometres, has been taking place for quite some time. Not least because of the energy transition, diverging claims regarding underground utilization are increasing. In addition to established uses (e.g. extraction of mineral waters or landfilling) there is an increasing use of deep geothermal energy and energy storage (e.g. in the form of hydrogen, methane, or by underground pumped storage plants) and relatively new energy generation methods including fracking. Furthermore underground space may be utilized in the future for storing greenhouse gases (CCS). These competing uses will converge to intensify pressure on the future use of subterranean space.

At present decisions concerning the use of underground space in Germany are decided on the basis of mining law. The appropriateness of this process is increasingly in doubt. Doubts are partly expressed regarding the law's capacity to deal with environmental risks, because mining law does not provide a reasonable structure for comprehensive consideration of spatial and cross-sectoral environmental risks or for appropriate public participation. The expected conflicts over underground space require both spatial and temporal coordination to settle conflicting uses. A special challenge is the need for a long term perspective on underground uses because they cause irreversible and massive impacts to the soil resource. In consequence a coordination decision that takes into account the underground space is not only useful and necessary to eliminate conflicts regarding underground usage, but also to cope with possible conflicts between spatial uses on the surface and the underground and to balance current and future demands on the soil.

This talk will discuss the factual and legal issues of underground uses and present possible solutions. This includes the options for an altered mining law, the establishment of sectoral planning law for mining and the possibilities of "spatial planning for underground space". The discussion will take into account practical examples from Germany and Switzerland where legal changes to establish instruments for a spatial planning law regarding underground space have recently been created.

Abstracts by last name